A-LEVEL PHYSICS • EXERCISE SHEET

20.3 Force on a moving charge

Name: _____ Class: _____ Date: _____ **Total: 13 marks**

Objective

Build the skills to answer exam questions on the **force on a moving charge** in a magnetic field.

You must be able to:

- use $F = BQv\sin\theta$ and find the force direction
- describe the **circular motion** of a charge in a uniform field
- explain the **Hall voltage** and **velocity selection**

1 Worked examples

Study these first. Each one shows the method for a question type used later —follow the steps and you can do the Practice and Exam-style questions yourself.

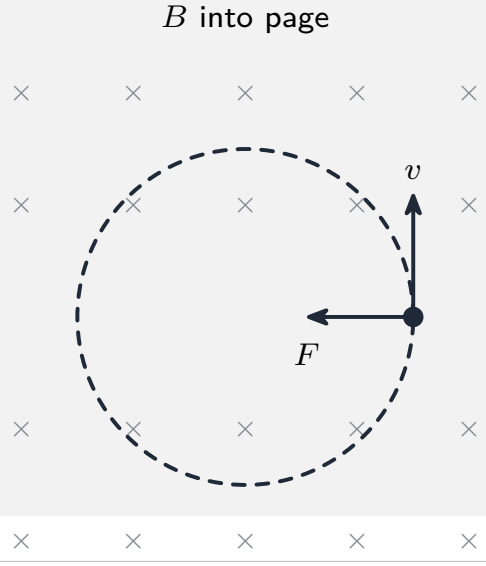
Force on a moving charge

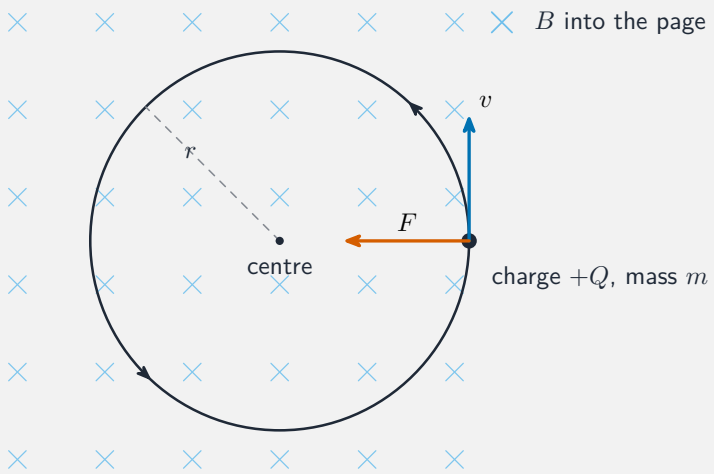
$$F = BQv\sin\theta.$$

Maximum when v is at right angles to B; zero when v is along B.

Circular motion

A charge moving **perpendicular** to a uniform field feels a force at right angles to v —so it moves in a **circle** at constant speed (the force does **no work**):





$$BQv = \frac{mv^2}{r} \Rightarrow r = \frac{mv}{BQ}$$

A moving charge curves in a magnetic field

Set magnetic force = centripetal force: $BQv = \dfrac{mv^2}{r}$, so $r = \dfrac{mv}{BQ}$.

A **velocity selector** uses crossed electric and magnetic fields: only charges with $v = E/B$ (where the forces balance) pass straight through.

2 Practice

Now apply the methods above.

2.1 Write the equation for the force on a moving charge. [1]

2.2 A charge of 1.6×10^{-19} C moves at 2.0×10^{6} m s^{-1} at right angles to a 0.50 T field. Find the force. [2]

2.3 State the **path** of a charge moving perpendicular to a uniform magnetic field. [1]

2.4 State **why** the magnetic force does **no work** on the moving charge. [1]

3 Exam-style questions

3.1 A charged particle moving **perpendicular** to a uniform field follows: [1]

- **A** a straight line
- **B** a parabola
- **C** a circle
- **D** a spreading spiral

3.2 An electron ($m = 9.1 \times 10^{-31}$ kg, $q = 1.6 \times 10^{-19}$ C) moves at 3.0×10^{6} m s^{-1} at right angles to a 0.020 T field. Calculate the **radius** of its circular path. [3]

3.3 Explain why the **speed** of the particle stays constant. [2]

3.4 Describe how a **velocity selector** selects charges of one particular speed. [2]

4 Go further

You are now ready for the real exam questions on this subtopic. Open the **20.3 Force on a moving charge** past-paper sheet in the Library, or try these in **Practice mode**:

- 9702/43 J25 —Q7 (force on a moving charge)
- 9702/42 M25 —Q6 (charged particle in a magnetic field)

Solutions

2.1 $F = BQv\sin\theta$.

2.2 $F = BQv = (0.50)(1.6\times10^{-19})(2.0\times10^{6}) = 1.6\times10^{-13}$ N.

2.3 A **circle**.

2.4 The force is always **perpendicular** to the velocity, so it does no work (the speed is unchanged).

3.1 **C** —a circle.

3.2 $BQv = \dfrac{mv^2}{r} \Rightarrow r = \dfrac{mv}{BQ} = \dfrac{(9.1\times10^{-31})(3.0\times10^{6})}{(0.020)(1.6\times10^{-19})} = 8.5\times10^{-4}$ m.

3.3 The magnetic force is always **perpendicular** to the velocity, so it does **no work** — the kinetic energy and hence speed stay constant.

3.4 Crossed **electric** and **magnetic** fields exert opposite forces on the charge; only when they **balance** ($qE = Bqv$, i.e. $v = E/B$) does the charge travel straight through — selecting that speed.